



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
NATIONAL EXPOSURE RESEARCH LABORATORY  
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF  
RESEARCH AND DEVELOPMENT

June 20, 2019

Mr. Clark Freise, Assistant Commissioner  
New Hampshire Department of Environmental Services (NHDES)  
29 Hazen Drive  
P.O. Box 95  
Concord, New Hampshire 03301

Dear Mr. Freise:

I am pleased to provide the enclosed 6<sup>th</sup> report from our ongoing collaborative technical support to NHDES assisting with concerns over per- and polyfluorinated alkyl substances (PFAS) environmental contamination associated with manufacturing sites. This report is in response to your October 2017 request asking for laboratory assistance analyzing per- and polyfluoroalkyl substances (PFAS) in stack emissions and stock solutions of dispersions and surfactants. The enclosed Report #6 provides non-targeted analysis laboratory results that tentatively identify various PFAS found in the Modified Method 5 (MM5) process emissions samples collected from select runs of the QX, MS, and MA towers.

It is our understanding that this information was requested by NHDES to help in their ongoing investigation into the presence of PFAS in the environment near manufacturing facilities of interest. This request relates to our research capabilities and interests applying targeted and non-targeted analysis methods for discovery of the nature and extent of PFAS environmental occurrence that may be potentially associated with industrial releases. EPA continues to develop analytical methods for many PFAS compounds in various media including some of those included in this report. We are providing the results of our analysis as they become available.

In this report, we provide PFAS tentative identification and semi-quantitative analytical results. We do not interpret exposure or risk from these values. EPA does not currently have health-based standards, toxicity factors, or associated risk levels for PFAS, other than perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and perfluorobutanesulfonic acid (PFBS). While the data provided in the attached reports indicate the presence (or lack) of PFAS in the MM5 samples, we do not have sufficient information to offer interpretations related to human or environmental exposure and risk.

Thank you for inviting us to be part of this effort that helps to further both EPA's and New Hampshire's understanding of an important issue in the state. This is just one of many Agency efforts that demonstrates EPA's commitment to cooperative federalism. If you have any questions or concerns, do not hesitate to contact me at (919) 541-2107 or via email at [watkins.tim@epa.gov](mailto:watkins.tim@epa.gov) or Tim Buckley at (919) 541-2454 or via email at [buckley.timothy@epa.gov](mailto:buckley.timothy@epa.gov). I look forward to our continued work together.

Sincerely,

*Timothy H. Watkins*

Timothy H. Watkins  
Director

Enclosure

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## PFAS Environmental Contamination Associated with Manufacturing Sites in New Hampshire

### Laboratory Data Report #6: Non-Targeted PFAS Measurements in MM5 Sample Trains

**Background.** The New Hampshire Department of Environmental Services (NHDES), in coordination with EPA Region 1, requested the Office of Research and Development's (ORD's) technical support in analyzing per- and polyfluoroalkyl substances (PFAS) in MM5 sampling trains collected from air emission stacks at a manufacturing site within the State of New Hampshire. NHDES assumed responsibility for the collection of samples and their shipment to the ORD laboratory. ORD was responsible for sample extraction and analysis. ORD's analysis and report team that contributed to this effort are listed in Table 1.

**Table 1. EPA Office of Research and Development analysis and report team.**

| Responsibility                     | Personnel                                      |
|------------------------------------|--|
| MM5 sampling expertise             | Jeff Ryan                                      |
| Laboratory chemistry               | James McCord, Dennis Tabor                     |
| Quality Assurance Review           | Sania Tong Argao                               |
| Management coordination and review | Kate Sullivan, Myriam Medina-Vera, Tim Buckley |
| Report Preparation                 | Kate Sullivan, Tim Buckley                     |

This 6<sup>th</sup> report includes non-targeted analysis (NTA) results for four MM5 sampling trains that were used to collect PFAS emissions from three separate process towers identified as QX, MA, and MS during Run 1 of the tests at an industrial site in New Hampshire. The QX tower had a pilot emissions control device (ECD) and for this tower, MM5 emissions samples were simultaneously collected at the inlet and the outlet of the control device for the purpose of evaluating the control efficiency. Samples were collected in August 2018. Each MM5 sampling train consists of multiple components including a front half filter (FHF), an XAD trap (XAD), three impingers in series, and a back half filter (BHF). There is also a methanol rinse (MeOH) sample component resulting from rinse of the front half of the train components. Each MM5 train component is extracted and analyzed separately, and results in 7 individual MeOH extracts for analyses. Results for this report are limited to the FHF, XAD, and BHF components of the MM5 sampling train where we expect the bulk of the PFAS to be captured. The results from the impinger and MeOH rinsate samples will be reported at a later time. Accordingly, we provide results for 12 samples (4 MM5 trains x 3 sample components/MM5 train = 12 sample components) in this report. In addition to the MM5 sample results, we also report results for 4 process blanks. The samples were sent to ORD's laboratory in Research Triangle Park, NC where they were extracted by Dennis Tabor and analyzed for PFAS under the direction of Dr. James McCord.

The current data report is intended to provide a simple representation and summary of the analysis results. Therefore, the description of methods and quality assurance are brief and high-level. Additional reports and/or publications may be developed that will include a more detailed description of methods, quality assurance procedures, and statistical interpretation of the data. As study partners/collaborators, we anticipate that NHDES and Region 1 will assist in these reports and publications.

**Methods in Brief.** The PFAS reported here were extracted and analyzed according to methods documented within an approved Quality Assurance Project Plan (QAPP)<sup>1</sup> and described in McCord et al. 2019.<sup>2</sup> In brief, the MM5 methanolic extracts were vortexed as received and diluted 50:50 with 2mM ammonium formate in water for liquid chromatography-mass spectrometry (LC-MS) analysis. LC-MS analysis was carried out on a Thermo Vanquish ultra-performance liquid chromatograph (UPLC) system coupled to a Thermo Orbitrap Fusion mass spectrometer. PFAS were analyzed using non-targeted analysis (NTA) methods. Non-targeted analysis provides two important measurements. The first is a tentative identification of PFAS compounds detected in the sample. PFAS are tentatively identified based on a combination of mass spectral data along with patterns of fragmentation compared to on-line and in-house mass-spectral libraries. Analytes in each sample and process blank were identified to various levels of confidence depending on how much combined evidence from manual examination of MS/MS fragmentation spectra and/or comparison with mass spectral libraries.

The second measurement is an indication of how much of the PFAS was present in the sample. The mass spectrometer detector provides integrated peak areas for the chromatogram of the compound mass (+/- 5ppm) at the specified retention time. The peak area counts are proportional to the mass of PFAS in the sample. Since the sample and injection volume are held constant, the peak area counts are also proportional to concentration. However, without a standard, we are not able to derive a mass or concentration value and results are considered semi-quantitative. Accordingly, we provide sample results as peak area counts. It is important to emphasize that instrument response is highly variable among analytes and between samples.

The non-targeted analytical data set generated by LC/MS are considered as a “detect” when acceptable chromatographic peaks and spectra were evident. We used a variety of process blanks to account for any PFAS contamination that may have occurred during sampling and analysis including trip, laboratory, and instrument blanks. Process blanks are important for evaluating processing and/or solvent contamination that is not attributable to the samples. Our peak area detection limit is established based on PFAS measured in laboratory and trip blanks provided to us. We report non-detect (ND) for peak areas that are <5 times the mean value observed in the corresponding laboratory or trip blanks.

**Summary of Results.** Across all the MM5 samples, we detected and tentatively identified 190 different PFAS. Of those, we have high confidence in the tentative identification of 89 compounds, which we report by formula, chemical compound name and CAS number where available, and monoisotopic mass (Table 2). All of these compounds have tentative formulas, but most of the identified PFAS are novel as indicated by the lack of a CAS registry number (n=83; 93%), or lack of compound name (n=60, 67%). Some of these PFAS may be registered in EPA’s CompTox dashboard where additional information can be found (U.S. EPA CompTox, 2019)<sup>3</sup>.

<sup>1</sup> National Exposure Research Laboratory, Quality Assurance Project Plan: Non-Targeted Analyses of Per- and Polyfluoroalkyl Substances (PFAS) for New Hampshire Department of Environmental Services (NHDES), October 2, 2017.

<sup>2</sup> McCord, J., Strynar, M. Identifying Per- and Polyfluorinated Chemical Species with a Combined Targeted and Non-Targeted-Screening High-Resolution Mass Spectrometry Workflow. *J. Vis. Exp.* (146), e59142, doi:10.3791/59142 (2019). <https://www.jove.com/video/59142/identifying-per-polyfluorinated-chemical-species-with-combined>

<sup>3</sup> U.S. EPA CompTox Chemicals Dashboard <https://comptox.epa.gov/dashboard>

In Table 3 we provide semi-quantitative results for the 89 PFAS found in the MM5 methanol extracts and corresponding trip blanks and instrument blank for the analytes identified in Table 2. Sample peak area counts are superimposed on a heat map where gradations in color reflect seven classifications of peak area from low (non-detect) to high (>1,000,000). The heat map is useful in showing the samples where PFAS was detected and their relative peak areas.

For both Tables 2 and 3, PFAS are ordered by largest to smallest peak area counts based on the QX tower ECD inlet XAD sample (702). The PFAS measured included chain lengths from C2 to C36 with the majority between C5 and C16. Most of the PFAS emissions, both in terms of the number of compounds and peak area counts, came from the QX tower. A comparison of inlet to outlet PFAS measurements at the pilot ECD suggests an attributable modest reduction across most of the PFAS, varying by analyte. Fewer PFAS and much lower peak areas were observed for PFAS measured at the MA and MS towers.

In summary, we tentatively identified and semi-quantified 89 PFAS from MM5 samples collected at emission towers at a manufacturing site in NH. Many of the PFAS are likely novel evident from predominantly absent CAS numbers. The QX tower stood out in terms of the frequency of PFAS detection and where the highest peak areas tended to occur.

**Table 2. Tentatively identified PFAS measured in MM5 samples.**

| <b>Compound #</b> | <b>Tentatively Identified Compound Name</b>                        | <b>Formula</b>    | <b>Monoisotopic Mass (g/mol)</b> |
|-------------------|--|-------------------|----------------------------------|
| 1                 | 6:1 Fluorotelomer ether alcohol (formate adduct); CAS 376-93-2     | C8 H5 F13 O4      | 411.9980                         |
| 2                 | 6:2 Fluorotelomer Unsaturated Carboxylic Acid (6:2 FTUCA)          | C8 H2 F12 O2      | 357.9862                         |
| 3                 | In-Source fragment, from 6:2 FTUCA                                 | C7 H F11          | 293.9901                         |
| 4                 | Perfluorohexanoic acid (PFHxA)                                     | C6 H F11 O2       | 313.9799                         |
| 5                 | In-Source fragment, from Perfluorohexanoic acid                    | C5 H F11          | 269.9903                         |
| 6                 | Unknown  | C15 H6 F22 O2     | 636.0020                         |
| 7                 | 6:2 Fluorotelomer ethoxycarboxylate (6:2 FTEOC); CAS 147011-35-6   | C10 H7 F13 O3     | 422.0189                         |
| 8                 | Perfluoroheptanoic acid (PFHpA)                                    | C7 H F13 O2       | 363.9771                         |
| 9                 | 6:1 Fluorotelomer ether alcohol (formate adduct); CAS 1452584-51-8 | C9 H7 F13 O3      | 410.0189                         |
| 10                | 6:1 Fluorotelomer alcohol  | C7 H3 F13 O       | 349.9975                         |
| 11                | Unknown  | C12 H11 F13 O4    | 466.0454                         |
| 12                | Unknown  | C20 H29 F13 O4    | 580.1864                         |
| 13                | Perfluoropentanoic acid (PFPeA)                                    | C5 H F9 O2        | 263.9835                         |
| 14                | 6:1 Fluorotelomer Alcohol (formate adduct)                         | C8 H5 F13 O3      | 396.0036                         |
| 15                | 2-Perfluorohexyl ethanoic acid; 6:2 FTA                            | C8 H3 F13 O2      | 377.9928                         |
| 16                | Unknown  | C8 H4 F11 N O     | 339.0120                         |
| 17                | Perfluoropropanoic acid (PFPA)                                     | C3 H F5 O2        | 163.9899                         |
| 18                | Unknown  | C12 H2 F22 O4     | 627.9610                         |
| 19                | Unknown  | C11 H12 F14 N4 O3 | 514.0676                         |
| 20                | Perfluorobutanoic acid (PFBA)                                      | C4 H F7 O2        | 213.9867                         |
| 21                | Fluorotelomer ethoxycarboxylate                                    | C14 H15 F13 O5    | 510.0722                         |
| 22                | Unknown  | C15 H14 F11 N O6  | 513.0647                         |
| 23                | Unknown  | C16 H4 F22 O3     | 661.9820                         |
| 24                | Unknown  | C10 H6 F12 O3     | 402.0127                         |
| 25                | 6:2 FETOC (formate adduct), 421.01154 + 46                         | C11 H9 F13 O5     | 468.0248                         |
| 26                | Fluorinated ethoxycarboxylate                                      | C17 H23 F13 O7    | 586.1247                         |
| 27                | 1-H Perfluoroheptanoic Acid  | C7 H2 F12 O2      | 345.9866                         |
| 28                | Unknown  | C16 H19 F13 O6    | 554.0988                         |
| 29                | PFECA; CAS 919005-00-8   | C5 H2 F8 O3       | 261.9881                         |
| 30                | Unknown  | C11 H9 F11 O3     | 398.0382                         |
| 31                | Unknown  | C7 H2 Cl F11 O    | 345.9628                         |
| 32                | Fluoroether Carboxylic Acid, 1-H Substituted; CAS 919005-00-8      | C5 H2 F8 O3       | 261.9877                         |
| 33                | Unknown  | C18 H4 F24 O3     | 723.9798                         |
| 34                | Unknown  | C11 H11 F11 O3    | 400.0545                         |
| 35                | Unknown  | C18 H18 F14 N4 O2 | 588.1192                         |
| 36                | Unknown  | C10 H10 F12 O5    | 438.0331                         |
| 37                | Unknown  | C12 H16 F12 O5    | 468.0804                         |
| 38                | C5 Fluorotelomer Methacrylate                                      | C11 H9 F11 O3     | 398.0382                         |
| 39                | Unknown  | C18 H27 F14 N5 O2 | 611.1920                         |
| 40                | Unknown  | C8 H8 F10 O5      | 374.0219                         |
| 41                | Unknown  | C13 H24 O2        | 212.1778                         |
| 42                | Unknown  | C13 H15 F11 O4    | 444.0801                         |
| 43                | Unknown  | C14 H13 F11 O3    | 438.0694                         |
| 44                | Unknown  | C13 H11 F11 O3    | 424.0540                         |
| 45                | Trifluoroacetic acid   | C2 H F3 O2        | 113.9933                         |
| 46                | Unknown  | C22 H47 F N4 O5   | 466.3508                         |
| 47                | Unknown  | C19 H27 F13 O4    | 566.1709                         |

| Compound # | Tentatively Identified Compound Name | Formula            | Monoisotopic Mass (g/mol) |
|------------|--------------------------------------|--------------------|---------------------------|
| 48         | Unknown                              | C24 H44 O20        | 652.2444                  |
| 49         | Unknown                              | C13 H7 F23 O3      | 648.0025                  |
| 50         | Unknown                              | C11 H10 F14 N4 O3  | 512.0513                  |
| 51         | Unknown                              | C15 H15 F11 O3     | 452.0853                  |
| 52         | 2H,2H,3H,3H-Perfluorooctanoic acid   | C8 H5 F11 O2       | 342.0117                  |
| 53         | Adduct or parent of 643.99542        | C15 H4 F23 N5 O    | 707.0031                  |
| 54         | 8:2 Fluorotelomer sulfonic acid      | C10 H5 F17 O3 S    | 527.9683                  |
| 55         | Unknown                              | C9 H5 F11 O3       | 370.0065                  |
| 56         | Unknown                              | C10 H7 F17 N4 O13  | 713.9754                  |
| 57         | Unknown                              | C16 H20 F14 N4 O4  | 598.1253                  |
| 58         | 1-H Perfluorohexanoic acid           | C6 H2 F10 O2       | 295.9895                  |
| 59         | Unknown                              | C12 H6 F24 N4 O2   | 694.0091                  |
| 60         | Unknown                              | C10 H7 F13 O4      | 438.0142                  |
| 61         | Unknown                              | C6 H5 F9 O4        | 312.0048                  |
| 62         | Unknown                              | C11 H14 F12 O4     | 438.0694                  |
| 63         | Unknown                              | C22 H19 F27 N4 O5  | 932.0918                  |
| 64         | Unknown                              | C32 H47 F13 N4 O7  | 846.3238                  |
| 65         | Unknown                              | C12 H10 F14 N4 O3  | 524.0518                  |
| 66         | Unknown                              | C20 H29 F7 N2 O7 S | 574.1593                  |
| 67         | Unknown                              | C5 H3 F11 N4 O     | 344.0125                  |
| 68         | Unknown                              | C7 H4 F10 O4       | 341.9951                  |
| 69         | Unknown                              | C13 H11 F11 O3     | 424.0540                  |
| 70         | PFECA; CAS 919005-00-8               | C5 H2 F8 O3        | 261.9882                  |
| 71         | Unknown                              | C15 H15 F11 O3     | 452.0853                  |
| 72         | Unknown                              | C10 H9 F11 O3      | 386.0380                  |
| 73         | Unknown                              | C12 H8 F24 N4 O    | 680.0286                  |
| 74         | Unknown                              | C36 H61 F13 O13    | 948.3913                  |
| 75         | Unknown                              | C6 H5 F11 O3       | 334.0064                  |
| 76         | Perfluorononanoic acid (PFNA)        | C9 H F17 O2        | 463.9713                  |
| 77         | Unknown                              | C14 H14 F12 N4     | 466.1012                  |
| 78         | Unknown                              | C13 H18 F12 O5     | 482.0960                  |
| 79         | Unknown                              | C10 H F14 N O2     | 432.9790                  |
| 80         | Unknown                              | C11 H9 F11 O3      | 398.0382                  |
| 81         | Unknown                              | C8 H5 F11 O3       | 358.0062                  |
| 82         | Unknown                              | C15 H6 F22 O3      | 651.9987                  |
| 83         | Unknown                              | C10 H9 F11 O3      | 386.0380                  |
| 84         | Unknown                              | C15 H22 F12 O5     | 510.1283                  |
| 85         | Unknown                              | C8 H7 F11 O4       | 376.0170                  |
| 86         | Unknown                              | C15 H9 F23 N4 O3   | 730.0294                  |
| 87         | Perfluorooctanoic Acid (PFOA)        | C8 H F15 O2        | 413.9744                  |
| 88         | Unknown                              | C8 H5 F12 N O4     | 407.0022                  |
| 89         | Unknown                              | C13 H4 F23 N O4    | 674.9776                  |

**Table 3. Detection and measurement of PFAS in MM5 samples. Results are reported as peak area units. Table cells are color-coded to indicate detection and peak area class.**

| Formula           | Compound # | QX Tower (Inlet)               |                          | QX Tower (Outlet)               |                           |                                 | MA Tower                  |                          |                    | MS Tower                 |                          |                    | Blanks                   |                            |                      |                            |                  |
|-------------------|------------|--------------------------------|--------------------------|---------------------------------|---------------------------|---------------------------------|---------------------------|--------------------------|--------------------|--------------------------|--------------------------|--------------------|--------------------------|----------------------------|----------------------|----------------------------|------------------|
|                   |            | QX Tower Inlet FH Filter (700) | QX Tower Inlet XAD (702) | QX Tower Outlet FH Filter (706) | QX Tower Outlet XAD (800) | QX Tower Outlet FH Filter (802) | QX Tower Outlet XAD (802) | MA Tower FH Filter (806) | MA Tower XAD (502) | MA Tower BH Filter (506) | MS Tower FH Filter (600) | MS Tower XAD (602) | MS Tower BH Filter (606) | Trip Blank FH Filter (200) | Trip Blank XAD (202) | Trip Blank BH Filter (205) | Laboratory (206) |
| C8 H5 F13 O4      | 1          | 70,500                         | 66,400,000               | 88,100                          | ND                        | 18,500,000                      | 13,700                    | ND                       | ND                 | ND                       | 10,000                   | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H2 F12 O2      | 2          | 399,000                        | 51,800,000               | 110,000                         | 354,000                   | 9,270,000                       | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C7 H F11          | 3          | 210,000                        | 26,000,000               | 54,000                          | 173,000                   | 4,000,000                       | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C6 H F11 O2       | 4          | 469,000                        | 23,400,000               | 246,000                         | 713,000                   | 34,000,000                      | 71,100                    | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C5 H F11          | 5          | 282,000                        | 17,700,000               | 140,000                         | 388,000                   | 20,100,000                      | 29,700                    | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C15 H6 F22 O2     | 6          | ND                             | 13,500,000               | 26,300                          | ND                        | 5,840,000                       | 6,030                     | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H7 F13 O3     | 7          | 104,000                        | 9,840,000                | 81,700                          | 116,000                   | 1,050,000                       | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C7 H F13 O2       | 8          | 47,800                         | 7,080,000                | 63,000                          | 121,000                   | 656,000                         | 3,370                     | 3,540                    | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C9 H7 F13 O3      | 9          | 20,500                         | 5,180,000                | 196                             | 1,500                     | 6,750,000                       | ND                        | ND                       | 1,080              | ND                       | ND                       | 192                | ND                       | ND                         | ND                   | ND                         | ND               |
| C7 H3 F13 O       | 10         | 6,620                          | 4,430,000                | 11,100                          | ND                        | 1,260,000                       | 1,210                     | ND                       | 814                | ND                       | ND                       | 477                | ND                       | ND                         | ND                   | ND                         | ND               |
| C12 H11 F13 O4    | 11         | 95,400                         | 3,800,000                | 154,000                         | 59,600                    | 11,500                          | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C20 H29 F13 O4    | 12         | ND                             | 3,330,000                | 223                             | ND                        | 1,320,000                       | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C5 H F9 O2        | 13         | 231,000                        | 3,040,000                | 104,000                         | 518,000                   | ND                              | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 39,400               | ND                         | ND               |
| C8 H5 F13 O3      | 14         | 1,020                          | 2,480,000                | ND                              | ND                        | 443,000                         | ND                        | ND                       | 2,350              | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H3 F13 O2      | 15         | 21,100                         | 2,370,000                | 5,060                           | 3,090                     | 213,000                         | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H4 F11 N O     | 16         | 9,300                          | 2,140,000                | 1,630                           | ND                        | 116,000                         | 713                       | ND                       | 1,230              | ND                       | ND                       | 731                | ND                       | ND                         | ND                   | ND                         | ND               |
| C3 H F5 O2        | 17         | 58,600                         | 2,070,000                | 6,970                           | 134,000                   | 120,000                         | ND                        | ND                       | 333,000            | ND                       | ND                       | 130,000            | ND                       | ND                         | ND                   | ND                         | ND               |
| C12 H2 F22 O4     | 18         | 14,800                         | 2,030,000                | 4,510                           | 43,900                    | 1,960,000                       | 231                       | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C11 H12 F14 N4 O3 | 19         | 28,900                         | 1,770,000                | 8,390                           | 1,890                     | 73,600                          | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C4 H F7 O2        | 20         | 92,400                         | 1,580,000                | 34,400                          | 285,000                   | 289,000                         | 1,450                     | ND                       | 2,850              | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C14 H15 F13 O5    | 21         | 81,900                         | 1,470,000                | 76,300                          | 12,600                    | ND                              | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C15 H14 F11 N O6  | 22         | 28,700                         | 1,440,000                | 1,560                           | ND                        | 376,000                         | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C16 H4 F22 O3     | 23         | ND                             | 1,200,000                | 126                             | ND                        | 1,890,000                       | 211                       | ND                       | 134                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H6 F12 O3     | 24         | 14,100                         | 1,060,000                | 15,100                          | 33,300                    | 133,000                         | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C11 H9 F13 O5     | 25         | 9,130                          | 915,000                  | 19,800                          | 41,100                    | 116,000                         | ND                        | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |

|                   |            | QX Tower (Inlet)               |                          |                                 | QX Tower (Outlet)               |                           |                                 | MA Tower                 |                    |                          | MS Tower                 |                    |                          | Blanks                     |                      |                            |                  |
|-------------------|------------|--------------------------------|--------------------------|---------------------------------|---------------------------------|---------------------------|---------------------------------|--------------------------|--------------------|--------------------------|--------------------------|--------------------|--------------------------|----------------------------|----------------------|----------------------------|------------------|
| Formula           | Compound # | QX Tower Inlet FH Filter (700) | QX Tower Inlet XAD (702) | QX Tower Outlet FH Filter (706) | QX Tower Outlet FH Filter (800) | QX Tower Outlet XAD (802) | QX Tower Outlet BH Filter (806) | MA Tower FH Filter (500) | MA Tower XAD (502) | MA Tower BH Filter (506) | MS Tower FH Filter (600) | MS Tower XAD (602) | MS Tower BH Filter (606) | Trip Blank FH Filter (200) | Trip Blank XAD (202) | Trip Blank BH Filter (205) | Laboratory (206) |
| C17 H23 F13 O7    | 26         | 60,100                         | 896,000                  | 48,100                          | 18,200                          | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C7 H2 F12 O2      | 27         | 5,030                          | 820,000                  | 2,080                           | 72,400                          | 32,100                    | ND                              | 1,210                    | 1,990              | ND                       | ND                       | 894                | ND                       | ND                         | ND                   | ND                         | ND               |
| C16 H19 F13 O6    | 28         | 72,800                         | 619,000                  | 39,000                          | 5,420                           | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C5 H2 F8 O3       | 29         | 127,000                        | 585,000                  | 8,650                           | 26,400                          | 340,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | 18,600             | ND                       | ND                         | ND                   | ND                         | ND               |
| C11 H9 F11 O3     | 30         | ND                             | 439,000                  | ND                              | ND                              | 50,200                    | ND                              | ND                       | 1,370              | ND                       | ND                       | 819                | ND                       | ND                         | ND                   | ND                         | ND               |
| C7 H2 Cl F11 O    | 31         | 124                            | 428,000                  | ND                              | ND                              | 194,000                   | ND                              | ND                       | 267                | ND                       | ND                       | 211                | ND                       | ND                         | ND                   | ND                         | ND               |
| C5 H2 F8 O3       | 32         | 127,000                        | 413,000                  | 244,000                         | 916,000                         | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C18 H4 F24 O3     | 33         | 390                            | 381,000                  | 2,620                           | ND                              | 9,230                     | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C11 H11 F11 O3    | 34         | ND                             | 367,000                  | 172                             | ND                              | 143,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C18 H18 F14 N4 O2 | 35         | ND                             | 367,000                  | ND                              | ND                              | 133,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | 1,230              | ND                       | ND                         | 231                  | ND                         | ND               |
| C10 H10 F12 O5    | 36         | ND                             | 362,000                  | ND                              | ND                              | 47,100                    | ND                              | ND                       | 524                | ND                       | ND                       | 256                | ND                       | ND                         | ND                   | ND                         | ND               |
| C12 H16 F12 O5    | 37         | ND                             | 351,000                  | ND                              | ND                              | 467,000                   | ND                              | ND                       | 145                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C11 H9 F11 O3     | 38         | ND                             | 300,000                  | ND                              | ND                              | 142,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C18 H27 F14 N5 O2 | 39         | ND                             | 294,000                  | ND                              | ND                              | 195,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H8 F10 O5      | 40         | 4,310                          | 291,000                  | 755                             | 66                              | 60,600                    | ND                              | ND                       | 85                 | ND                       | ND                       | 523                | ND                       | ND                         | ND                   | ND                         | ND               |
| C13 H24 O2        | 41         | 10,700                         | 291,000                  | ND                              | ND                              | ND                        | ND                              | ND                       | 209,000            | ND                       | ND                       | 20,100             | ND                       | ND                         | ND                   | ND                         | ND               |
| C13 H15 F11 O4    | 42         | ND                             | 284,000                  | ND                              | ND                              | 233,000                   | 55                              | ND                       | 168                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C14 H13 F11 O3    | 43         | ND                             | 281,000                  | ND                              | ND                              | 216,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C13 H11 F11 O3    | 44         | ND                             | 254,000                  | 146                             | ND                              | 16,900                    | ND                              | ND                       | 924                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C2 H F3 O2        | 45         | ND                             | ND                       | ND                              | ND                              | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 198,000              | ND                         | ND               |
| C22 H47 F4 N4 O5  | 46         | 127,000                        | 229,000                  | 2,170                           | 1,360                           | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 529                  | ND                         | ND               |
| C19 H27 F13 O4    | 47         | ND                             | 225,000                  | ND                              | ND                              | 62,600                    | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C24 H44 O20       | 48         | ND                             | 214,000                  | ND                              | ND                              | 175,000                   | 362                             | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C13 H7 F23 O3     | 49         | ND                             | 209,000                  | 177                             | ND                              | 106,000                   | ND                              | ND                       | 230                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C11 H10 F14 N4 O3 | 50         | 800                            | 206,000                  | 12,000                          | 4,750                           | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 441                  | ND                         | ND               |
| C15 H15 F11 O3    | 51         | ND                             | 197,000                  | ND                              | ND                              | 168,000                   | ND                              | ND                       | 125                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H5 F11 O2      | 52         | 210                            | 188,000                  | ND                              | ND                              | 358,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 231                  | ND                         | ND               |

|                    |            | QX Tower (Inlet)               |                          |                                 | QX Tower (Outlet)               |                           |                                 | MA Tower                 |                    |                          | MS Tower                 |                    |                          | Blanks                     |                      |                            |                  |
|--------------------|------------|--------------------------------|--------------------------|---------------------------------|---------------------------------|---------------------------|---------------------------------|--------------------------|--------------------|--------------------------|--------------------------|--------------------|--------------------------|----------------------------|----------------------|----------------------------|------------------|
| Formula            | Compound # | QX Tower Inlet FH Filter (700) | QX Tower Inlet XAD (702) | QX Tower Outlet FH Filter (706) | QX Tower Outlet FH Filter (800) | QX Tower Outlet XAD (802) | QX Tower Outlet BH Filter (806) | MA Tower FH Filter (500) | MA Tower XAD (502) | MA Tower BH Filter (506) | MS Tower FH Filter (600) | MS Tower XAD (602) | MS Tower BH Filter (606) | Trip Blank FH Filter (200) | Trip Blank XAD (202) | Trip Blank BH Filter (205) | Laboratory (206) |
| C15 H4 F23 N5 O    | 53         | ND                             | 185,000                  | ND                              | ND                              | 7,400                     | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H5 F17 O3 S    | 54         | 6,440                          | 176,000                  | 1,110                           | 39,200                          | 573                       | ND                              | ND                       | 88                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C9 H5 F11 O3       | 55         | 6,630                          | 170,000                  | 7,550                           | 14,600                          | 406,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H7 F17 N4 O13  | 56         | ND                             | 161,000                  | ND                              | ND                              | 23,300                    | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C16 H20 F14 N4 O4  | 57         | 107,000                        | 158,000                  | 12,900                          | 2,460                           | ND                        | ND                              | ND                       | 1,100              | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C6 H2 F10 O2       | 58         | 196                            | 157,000                  | 425                             | ND                              | 165,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | 1,210              | ND                       | ND                         | 237                  | ND                         | ND               |
| C12 H6 F24 N4 O2   | 59         | ND                             | 155,000                  | 171                             | ND                              | 73,600                    | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H7 F13 O4      | 60         | 2,590                          | 155,000                  | 1,420                           | 498                             | 4,320                     | ND                              | ND                       | 134                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C6 H5 F9 O4        | 61         | ND                             | 152,000                  | ND                              | ND                              | 34,800                    | ND                              | ND                       | 81                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C11 H14 F12 O4     | 62         | 147                            | 150,000                  | ND                              | ND                              | 79,100                    | ND                              | ND                       | 184                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C22 H19 F27 N4 O5  | 63         | ND                             | 148,000                  | 424                             | ND                              | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 154                  | ND                         | ND               |
| C32 H47 F13 N4 O7  | 64         | 136                            | 143,000                  | ND                              | ND                              | 55,400                    | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 326                  | ND                         | ND               |
| C12 H10 F14 N4 O3  | 65         | 10,000                         | 140,000                  | 9,050                           | 1,160                           | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 690                  | ND                         | ND               |
| C20 H29 F7 N2 O7 S | 66         | 523                            | 139,000                  | ND                              | ND                              | 4,770                     | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C5 H3 F11 N4 O     | 67         | 515                            | 133,000                  | ND                              | ND                              | 123,000                   | ND                              | ND                       | 188                | ND                       | ND                       | 612                | ND                       | ND                         | ND                   | ND                         | ND               |
| C7 H4 F10 O4       | 68         | 83                             | 127,000                  | ND                              | ND                              | 118,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 237                  | ND                         | ND               |
| C13 H11 F11 O3     | 69         | ND                             | 125,000                  | 129                             | ND                              | 73,700                    | ND                              | ND                       | 587                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C5 H2 F8 O3        | 70         | ND                             | 123,000                  | 3,600                           | ND                              | 340,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | 17,100             | ND                       | ND                         | ND                   | ND                         | ND               |
| C15 H15 F11 O3     | 71         | ND                             | 122,000                  | ND                              | ND                              | 97,500                    | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H9 F11 O3      | 72         | 326                            | 120,000                  | 85                              | ND                              | 204,000                   | 330                             | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C12 H8 F24 N4 O    | 73         | ND                             | 119,000                  | 131                             | ND                              | 8,210                     | ND                              | ND                       | 532                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C36 H61 F13 O13    | 74         | ND                             | 114,000                  | ND                              | ND                              | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 466                  | ND                         | ND               |
| C6 H5 F11 O3       | 75         | ND                             | 113,000                  | ND                              | ND                              | 14,900                    | ND                              | ND                       | 492                | ND                       | ND                       | 461                | ND                       | ND                         | ND                   | ND                         | ND               |
| C9 H F17 O2        | 76         | 721                            | 109,000                  | 8,050                           | ND                              | 5,110                     | ND                              | ND                       | ND                 | ND                       | ND                       | 2,260              | ND                       | ND                         | 442                  | ND                         | ND               |
| C14 H14 F12 N4     | 77         | ND                             | 107,000                  | 128                             | ND                              | 397,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C13 H18 F12 O5     | 78         | ND                             | 105,000                  | ND                              | ND                              | 96,300                    | ND                              | ND                       | 76                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H F14 N O2     | 79         | 495                            | 93,000                   | 423                             | ND                              | 158,000                   | 1,030                           | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 203                  | ND                         | ND               |

| Formula          | Compound # | QX Tower (Inlet)               |                          |                                 | QX Tower (Outlet)               |                           |                                 | MA Tower                 |                    |                          | MS Tower                 |                    |                          | Blanks                     |                      |                            |                  |
|------------------|------------|--------------------------------|--------------------------|---------------------------------|---------------------------------|---------------------------|---------------------------------|--------------------------|--------------------|--------------------------|--------------------------|--------------------|--------------------------|----------------------------|----------------------|----------------------------|------------------|
|                  |            | QX Tower Inlet FH Filter (700) | QX Tower Inlet XAD (702) | QX Tower Outlet FH Filter (706) | QX Tower Outlet FH Filter (800) | QX Tower Outlet XAD (802) | QX Tower Outlet BH Filter (806) | MA Tower FH Filter (500) | MA Tower XAD (502) | MA Tower BH Filter (506) | MS Tower FH Filter (600) | MS Tower XAD (602) | MS Tower BH Filter (606) | Trip Blank FH Filter (200) | Trip Blank XAD (202) | Trip Blank BH Filter (205) | Laboratory (206) |
| C11 H9 F11 O3    | 80         | ND                             | 86,900                   | 330                             | ND                              | 194,000                   | ND                              | ND                       | 184                | ND                       | ND                       | 138                | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H5 F11 O3     | 81         | 1,420                          | 86,500                   | ND                              | 433                             | 417,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 342                  | ND                         | ND               |
| C15 H6 F22 O3    | 82         | ND                             | 57,000                   | ND                              | ND                              | 149,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C10 H9 F11 O3    | 83         | 74                             | 51,600                   | 74                              | ND                              | 278,000                   | 219                             | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C15 H22 F12 O5   | 84         | ND                             | 44,400                   | ND                              | ND                              | 119,000                   | ND                              | ND                       | 125,000            | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H7 F11 O4     | 85         | 1,020                          | 35,600                   | 163                             | 309                             | 412,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 214                  | ND                         | ND               |
| C15 H9 F23 N4 O3 | 86         | ND                             | 21,600                   | ND                              | ND                              | 203,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |
| C8 H F15 O2      | 87         | ND                             | ND                       | ND                              | ND                              | ND                        | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | 69,500                   | ND                         | 164,000              | 1,470                      | ND               |
| C8 H5 F12 N O4   | 88         | ND                             | ND                       | ND                              | ND                              | 274,000                   | ND                              | ND                       | ND                 | ND                       | ND                       | ND                 | ND                       | ND                         | 878                  | ND                         | ND               |
| C13 H4 F23 N O4  | 89         | ND                             | 1,170                    | ND                              | ND                              | 114,000                   | ND                              | ND                       | 143                | ND                       | ND                       | ND                 | ND                       | ND                         | ND                   | ND                         | ND               |

**LEGEND**

| Color        | Peak Area as Relative Indicator of Abundance |
|--------------|--|
| ND           | <5x Method Blanks or Trip Blanks             |
| Green        | >5x blank to 30,000                          |
| Yellow-Green | 30,000 - 50,000                              |
| Yellow       | 50,000 - 100,000                             |
| Orange       | 100,000-400,000                              |
| Red-Orange   | 400,000 -1,000,000                           |
| Red          | >1,000,000                                   |